Class 11 Physics Chapter 9: Mechanical Properties of Solids

Very Short Answers

14. Young's modulus for steel is more than that for rubber. For the same longitudinal strain, which one will have greater tensile stress?

Answer: Young's modulus is given as: Y = (Tensile stress)/(Longitudinal strain)

When the longitudinal strain is the same for both, steel will have a greater tensile stress.

Since: $Y_{steel}/Y_{rubber} = Stress_{steel}/Stres_{rubber}$

And $Y_{steel}/Y_{rubber} > 1$, therefore $Stress_{steel} > Stress_{rubber}$

15. Is stress a vector quantity?

Answer: Stress is neither a scalar quantity nor a vector quantity. It is a tensor quantity. This is because stress is equal to the magnitude of the internal reaction force divided by the area of the cross-section, and its direction depends on the orientation of the surface.

16. Identical springs of steel and copper are equally stretched. On which, more work will have to be done?

Answer: When identical springs of steel and copper are equally stretched: $W \propto \Delta l$

Since the springs are identical, their length and area are the same. $\Delta l \propto 1/Y$

From both equations: $W_{steel}/W_{copper} = Y_{copper}/Y_{steel}$

Since $Y_{steel} > Y_{copper}$, therefore $W_{steel} < W_{copper}$

More work is done on the copper spring.

17. What is the Young's modulus for a perfect rigid body?

Answer: According to Hooke's law: Young's modulus = Stress/Longitudinal strain

For a perfectly rigid body, longitudinal strain = 0 Therefore: $Y = (F/A) \times (l/0) = \infty$

18. What is the Bulk modulus for a perfect rigid body?

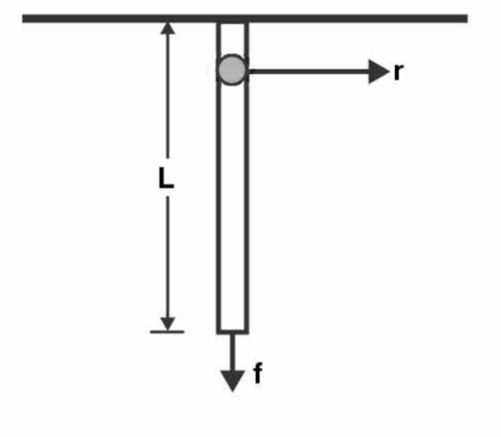
Answer: Bulk modulus is given as: $B = \text{Stress/Volume strain} = pV/\Delta V$

For a perfectly rigid body, $\Delta V = 0$ Therefore: $B = pV/0 = \infty$

Short Answers

19. A wire of length L and radius r is clamped rigidly at one end. When the other end of the wire is pulled by a force f, its length increases by l. Another wire of the same material of length 2L and radius 2r is pulled by force 2f. Find the increase in length of this wire.

Answer: From Young's modulus formula: $Y = (f/A)(L/l)$



First case:

- Length = L, Radius = r, Force = f, Extension = l
- $Y_1 = (f/\pi r^2)(L/l) = fL/(\pi r^2 l)$

Second case:

- Length = 2L, Radius = 2r, Force = 2f, Extension = x
- $Y_2 = (2f/\pi(2r)^2)(2L/x) = (2f/4\pi r^2)(2L/x) = fL/(\pi r^2 x)$

Since both wires are of the same material: $Y_1 = Y_2$ $fL/(\pi r^2 l) = fL/(\pi r^2 x)$ Therefore, x = l

20. A steel rod of length 1 m and area of cross-section 1 cm² is heated from 0°C to 200°C without being allowed to extend or bend. What is the tension produced in the rod?

Answer: Given:

- Young's modulus of steel, $Y = 2.0 \times 10^{11}$ N/m²
- Coefficient of thermal expansion, $\alpha = 10^{-5}$ °C⁻¹
- Length, L = 1 m
- Area of cross section A = 1 cm² = 1×10^{-4} m²
- Rise in temperature = 200°C

The thermal expansion that would occur: $\Delta L = \alpha L \Delta T = 10^{-5} \times 1 \times 200 = 2\times10^{-3}$ m

Since expansion is prevented, compression strain = $\Delta L/L = 2\times10^{-3}$

Using: $Y = (T/A)/(\Delta L/L)$ $T = Y \times A \times (\Delta L/L) = 2.0\times10^{11} \times 1\times10^{-4} \times 2\times10^{-3} = 4\times10^4$ N

21. To what depth must a rubber ball be taken in the deep sea so that its volume is decreased by 0.1%?

Answer: Given:

- Bulk modulus of rubber = 9.8×10^8 N/m²
- Density of sea water = 10^3 kg/m³
- Percentage decrease in volume = 0.1% = 0.1/100

Change in pressure: $p = h\rho g$ Bulk modulus: $B = \Delta P/(\Delta V/V)$

$\Delta P = B \times (\Delta V/V) = 9.8\times10^8 \times 0.001 = 9.8\times10^5$ N/m²

$h\rho g = 9.8\times10^5$ $h \times 10^3 \times 9.8 = 9.8\times10^5$ h = 100 m

22. A truck is pulling a car out of a ditch by means of a steel cable that is 9.1 m long and has a radius of 5 mm. When the car just begins to move, the tension in the cable is 800 N. How much has the cable stretched?

Answer: Given:

- Length of steel cable, l = 9.1 m
- Radius, r = 5 mm = 5×10^{-3} m
- Tension = 800 N
- Young's modulus of steel, Y = 2×10^{11} N/m²

Area = $\pi r^2 = \pi \times (5\times10^{-3})^2 = \pi \times 25\times10^{-6}$ m²

Using: $Y = (F/A)/(\Delta L/L)$ $\Delta L = FL/(AY) = (800 \times 9.1)/(\pi \times 25\times10^{-6} \times 2\times10^{11})$ $\Delta L = 7280/(\pi \times 25\times10^{-6} \times 2\times10^{11}) = 0.5\times10^{-3}$ m = 0.5 mm

23. Two identical solid balls, one of ivory and the other of wet clay, are dropped from the same height on the floor. Which one will rise to a greater height after striking the floor and why?

Answer: The ivory ball will rise to a greater height after striking the floor because ivory is more elastic than wet clay. The coefficient of restitution for ivory is higher than that for wet clay, meaning more kinetic energy is conserved during the collision. The wet clay undergoes more plastic deformation, dissipating more energy as heat and sound.